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Agapiou et al.

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(54) **METHOD OF MANUFACTURING AN INDUCTION ROTOR**

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(51) **Int. Cl.**

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H02K 15/09	(2006.01)
H02K 15/00	(2006.01)
H02K 17/28	(2006.01)
H02K 3/04	(2006.01)

(52) **U.S. Cl.**

CPC ***H02K 15/09*** (2013.01); ***H02K 3/04*** (2013.01); ***H02K 15/0012*** (2013.01); ***H02K 15/02*** (2013.01); ***H02K 17/28*** (2013.01); *Y10T 29/49012* (2015.01)

(58) **Field of Classification Search**

USPC 29/598, 596, 604, 609, 732, 738

See application file for complete search history.

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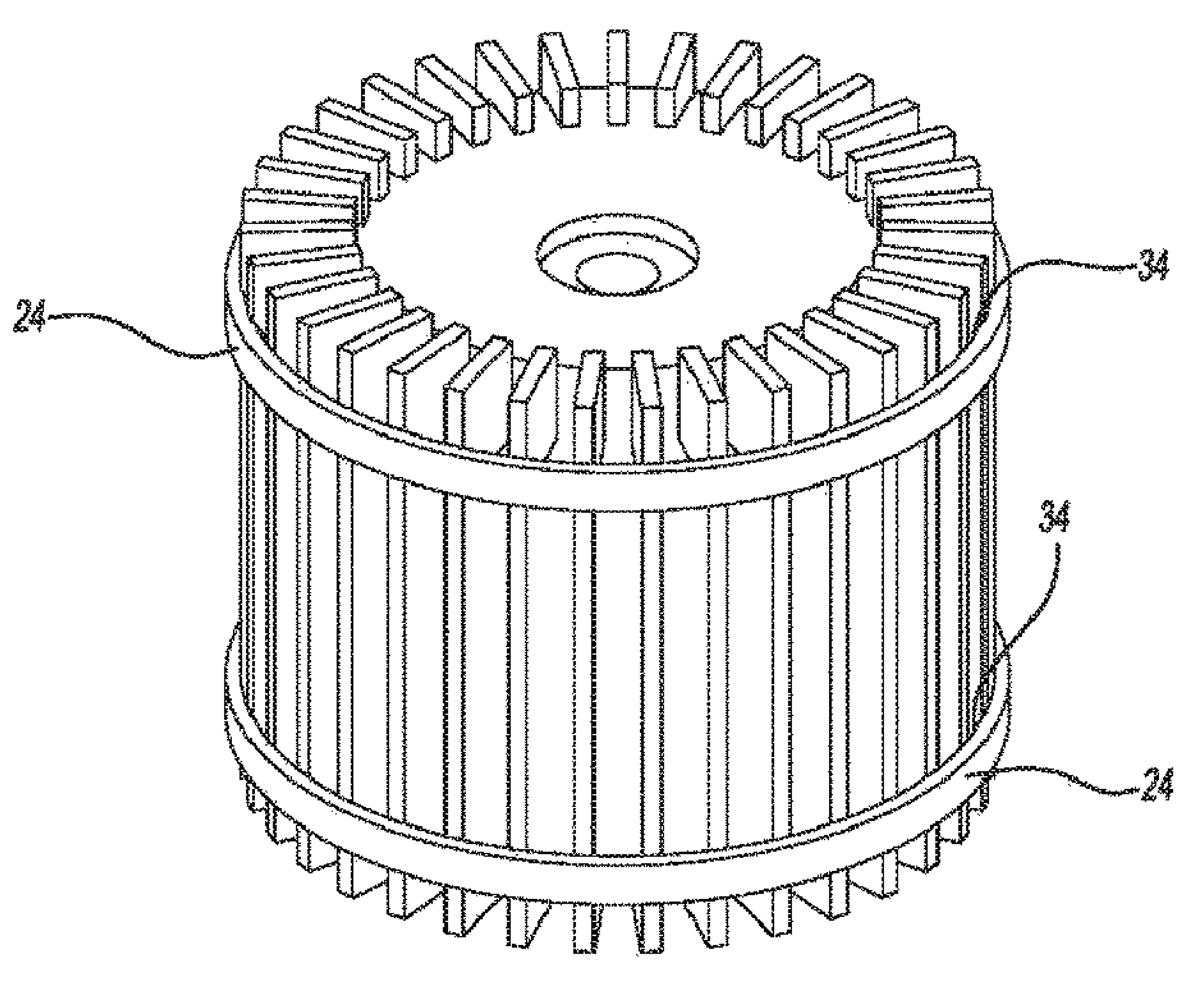
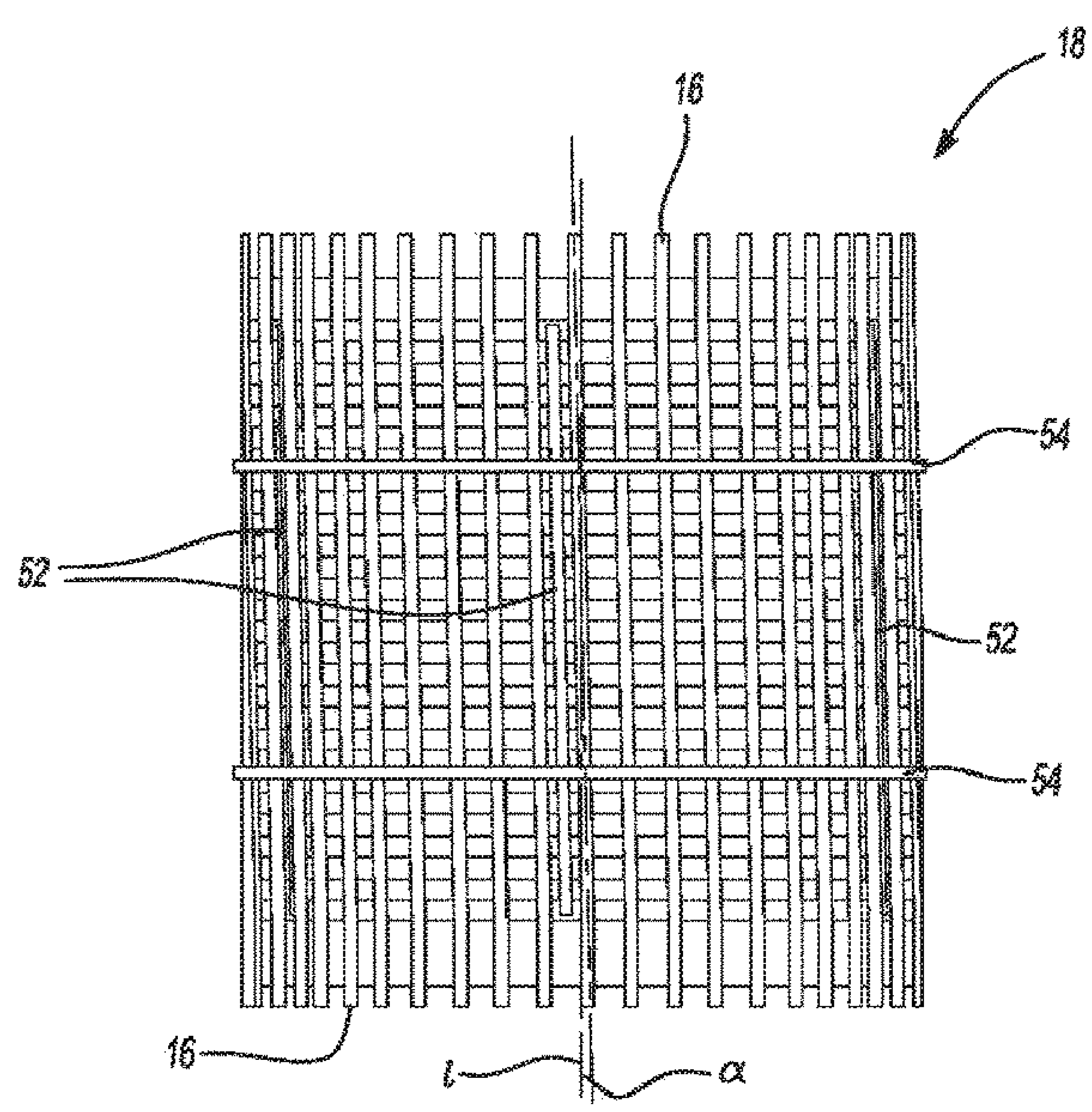
Primary Examiner — Thiem D Phan

(57) **ABSTRACT**

A method for manufacturing an induction rotor includes placing a lamination stack into a fixture in which the first end of the lamination stack is rotated in an opposite rotational direction from the second end of the lamination stack to skew the conduction bars to an angle α. Vertical members are fixed to an outer perimeter of each of the plurality of laminates of the lamination stack. Hoop members are fixed to each of the plurality of vertical members and an outer edge of each of the plurality of conduction bars. A conduction ring is fixed on each of the ends of the lamination stack. An outer perimeter of the lamination stack is machined to remove the plurality of vertical members and the plurality of hoop members from the lamination stack.

15 Claims, 6 Drawing Sheets





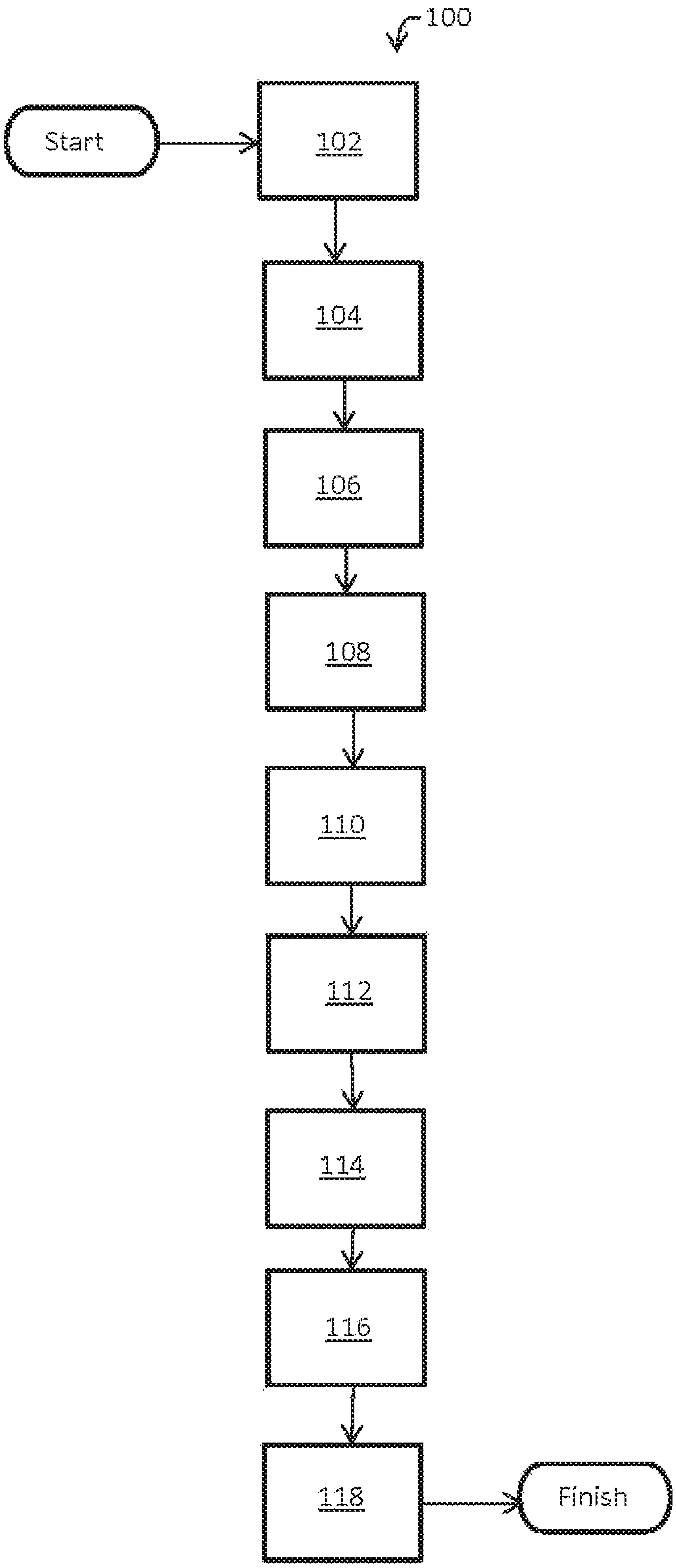


FIG. 1

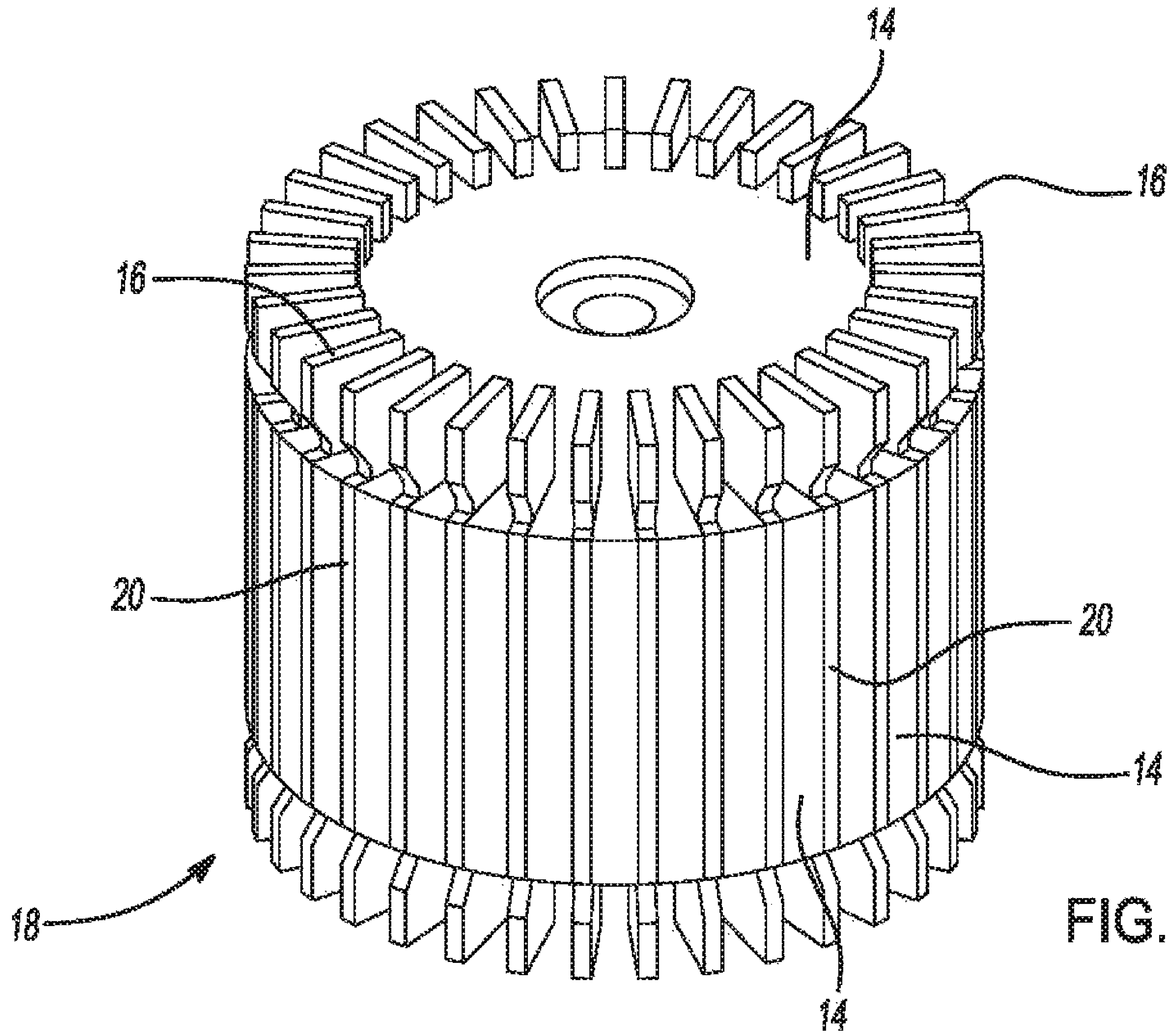


FIG. 2

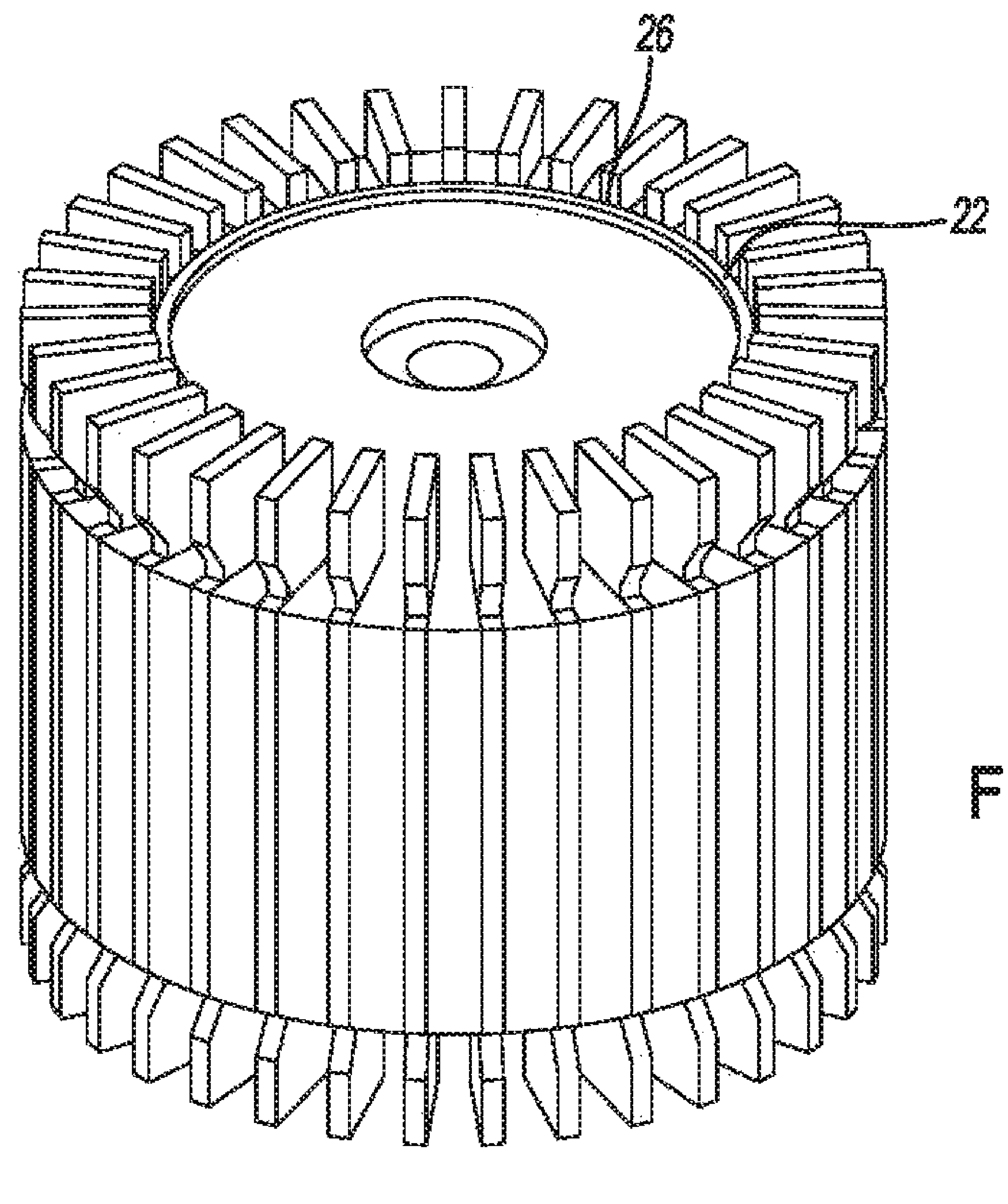


FIG. 3A

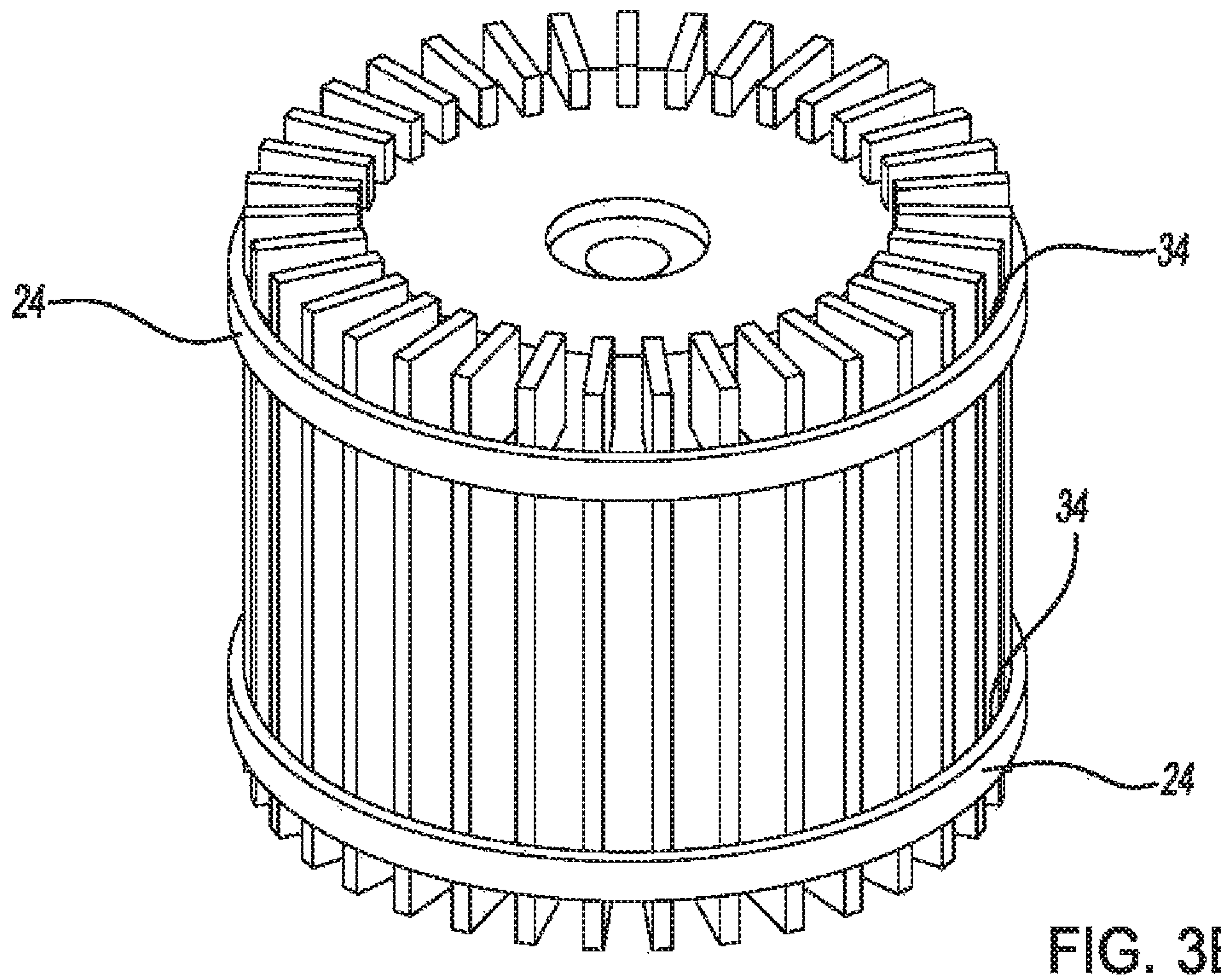


FIG. 3B

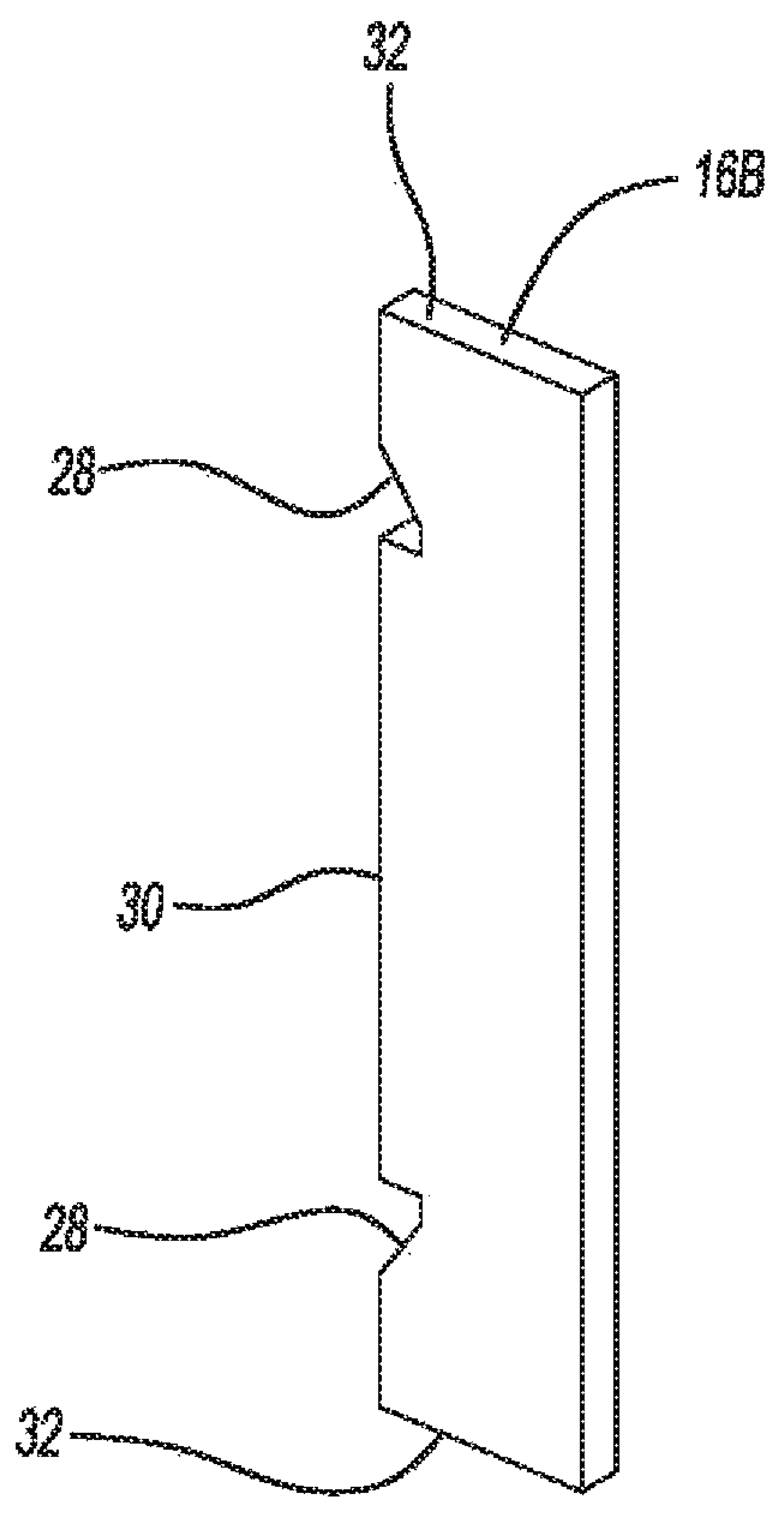


FIG. 4A

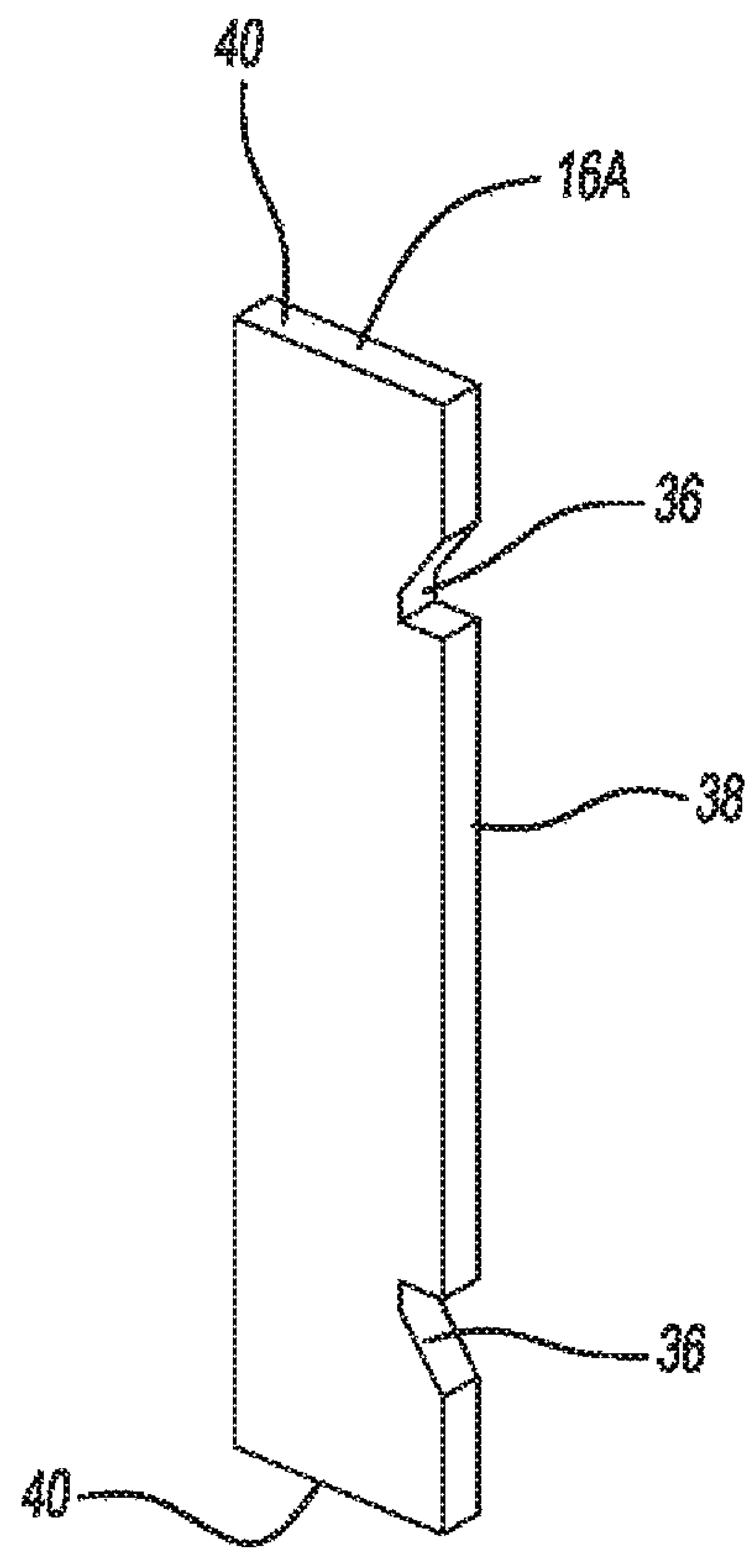


FIG. 4B

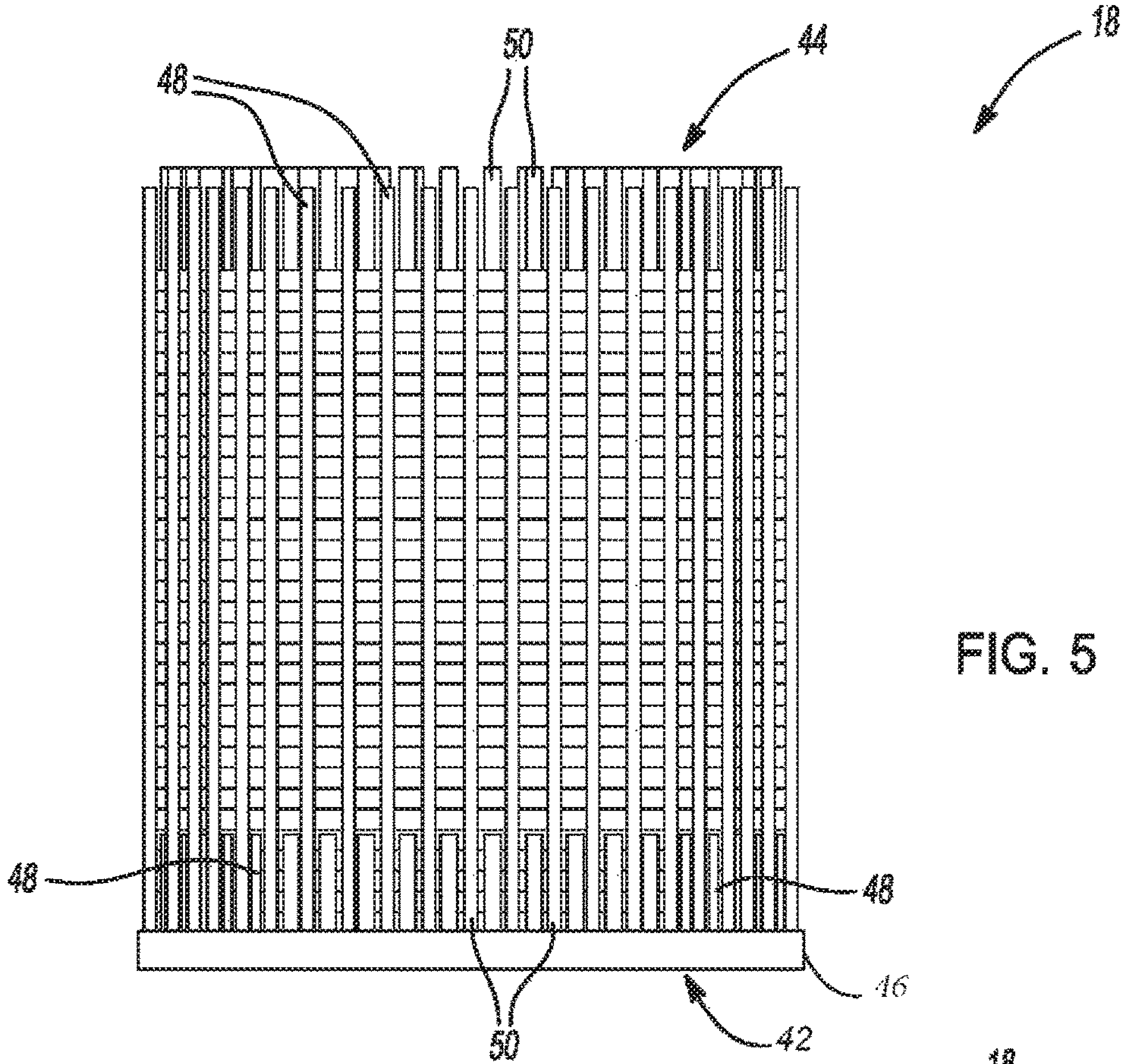


FIG. 5

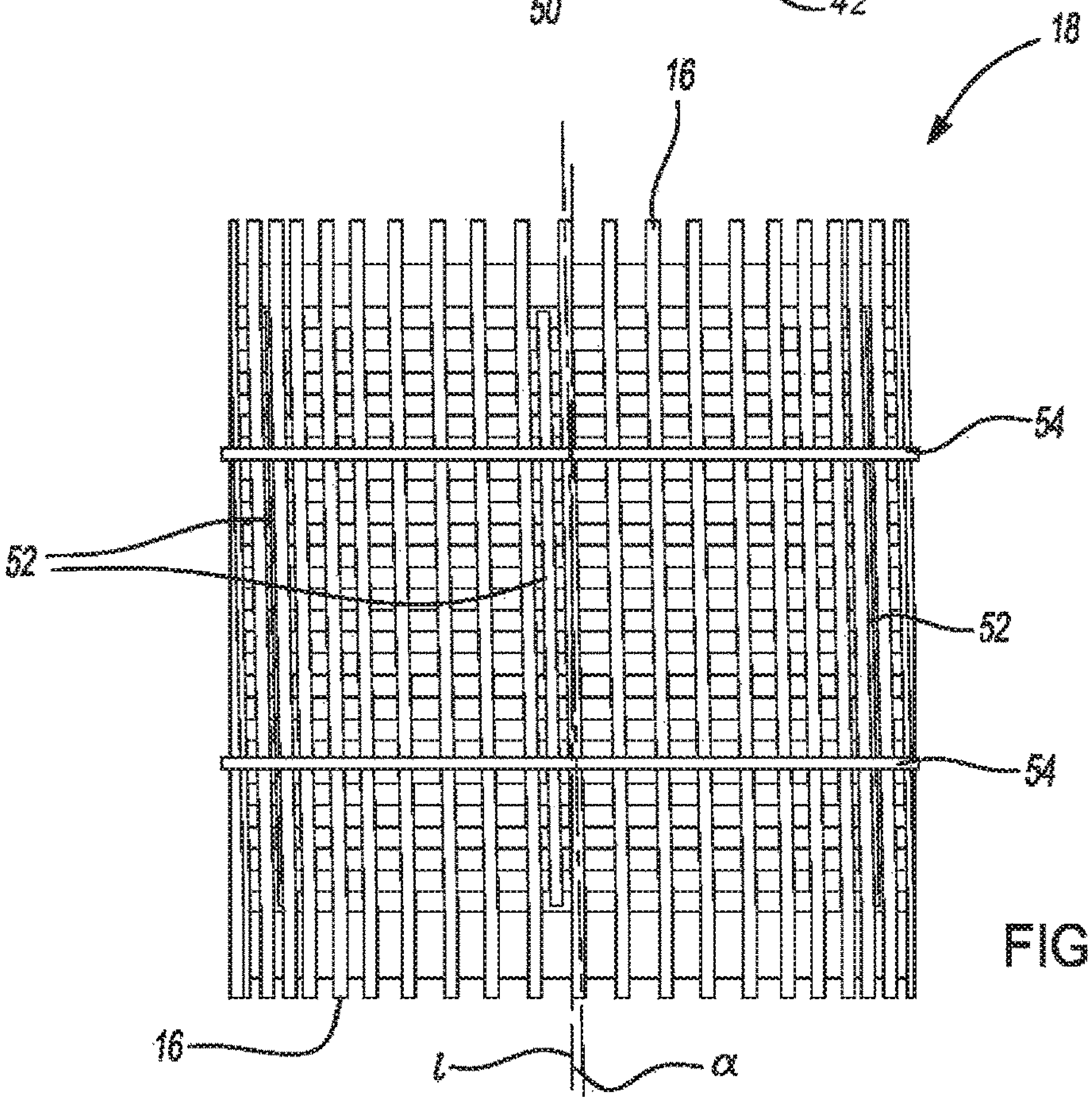


FIG. 6

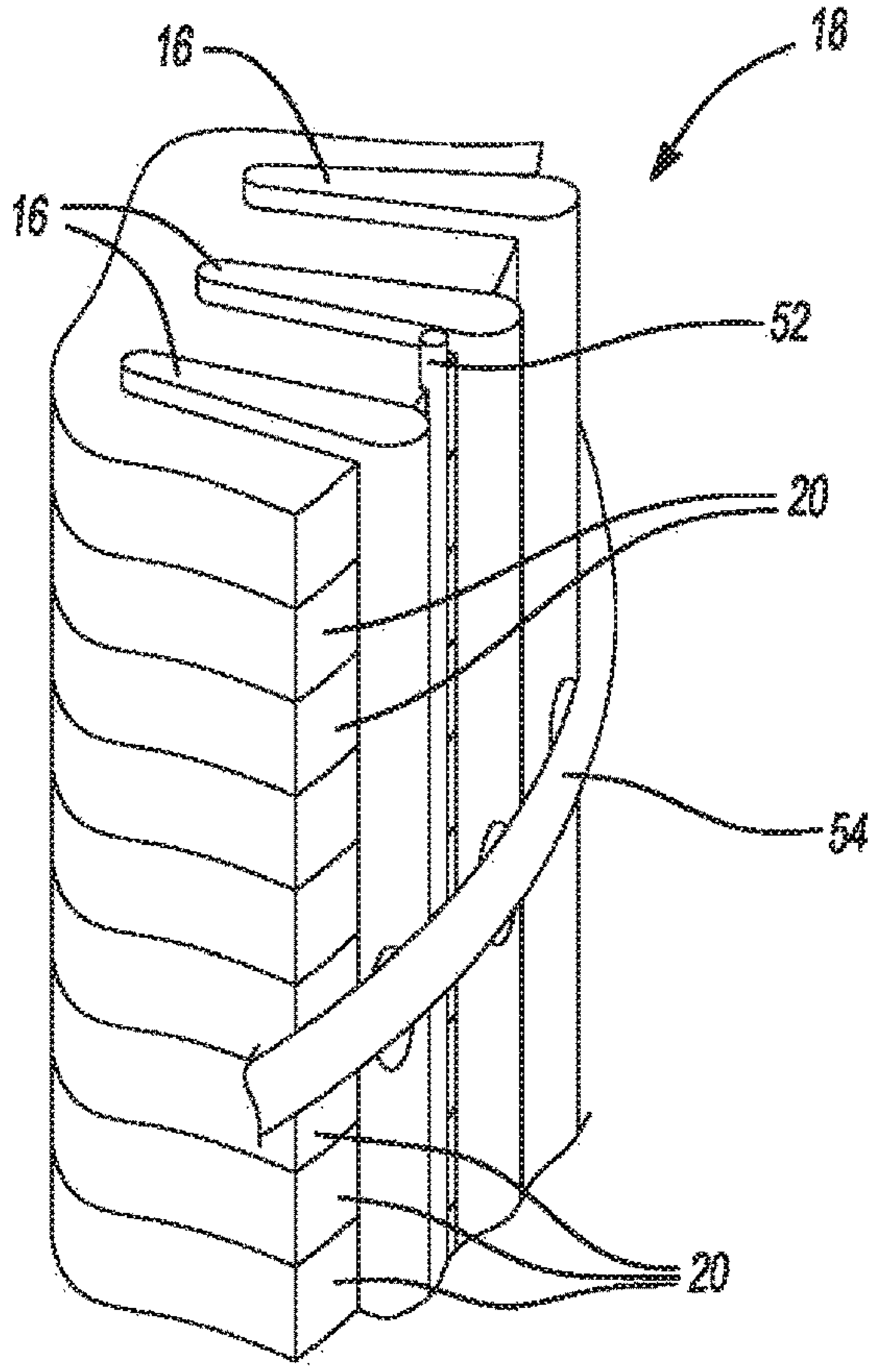


FIG. 7

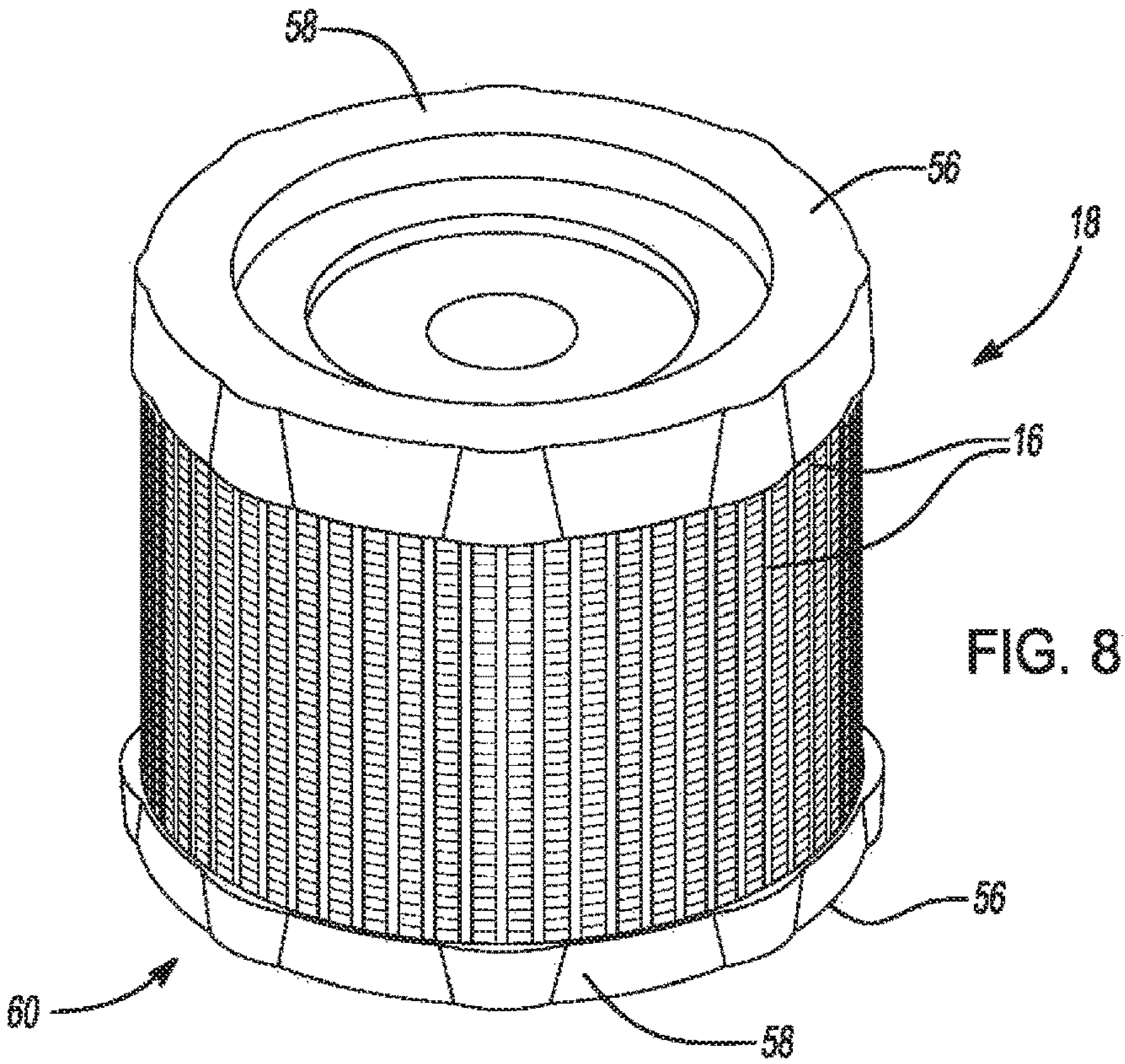


FIG. 8

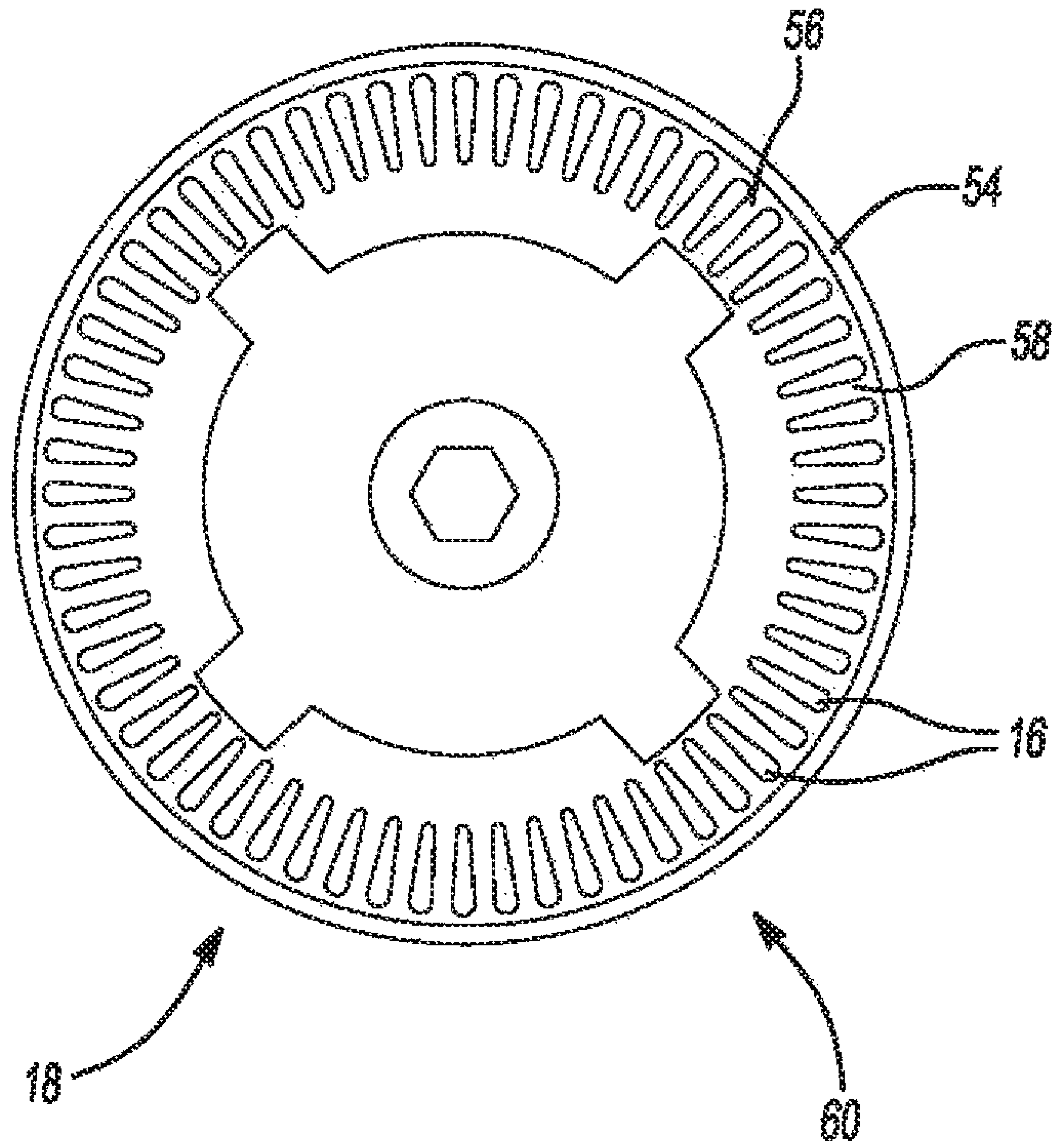


FIG. 9

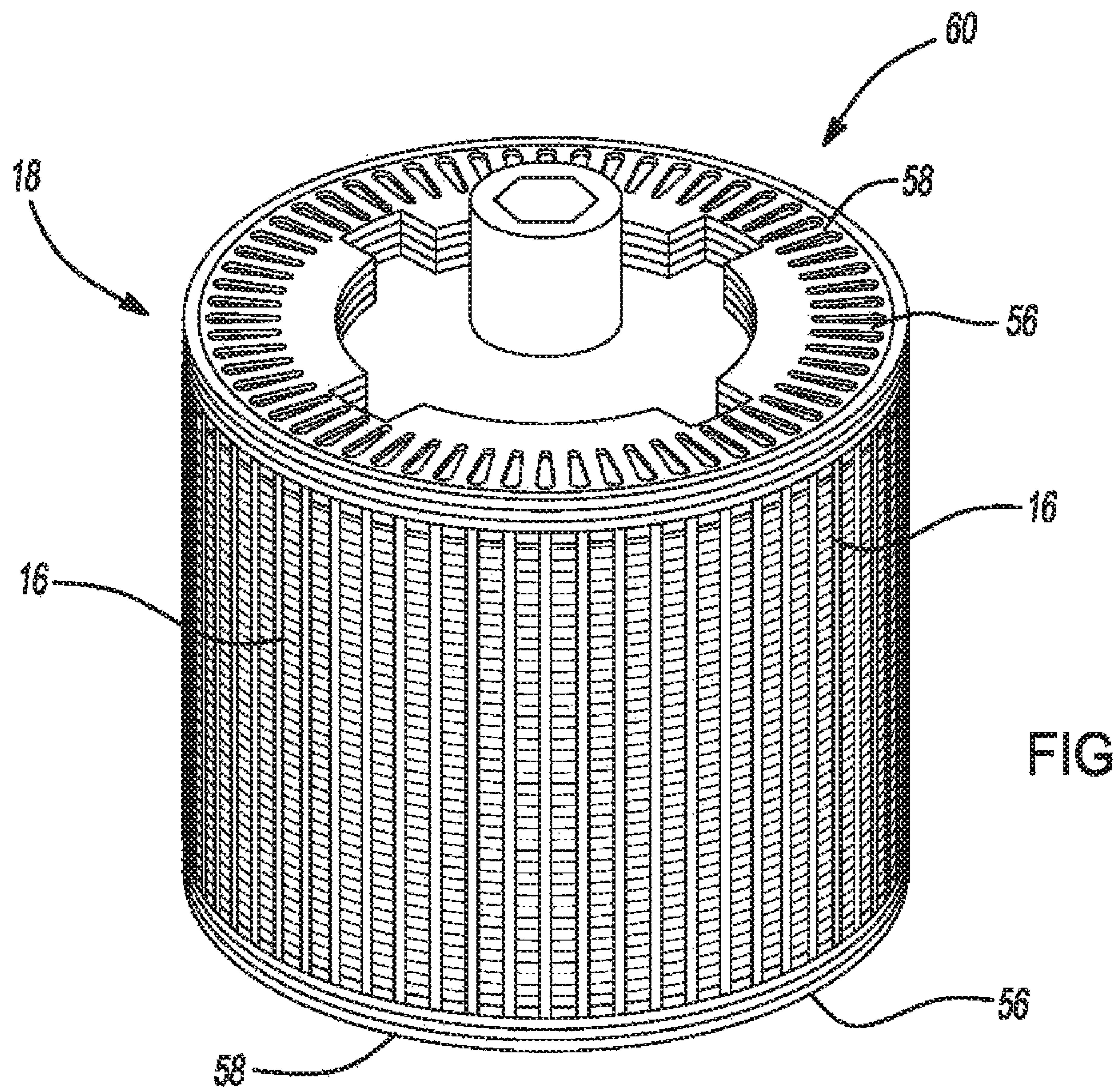


FIG. 10

METHOD OF MANUFACTURING AN INDUCTION ROTOR

INTRODUCTION

The present disclosure relates generally to the manufacture of induction-type electric motors, and more particularly to a method of manufacturing induction rotors.

Development of induction rotors for use in induction-type electric motors has found that including conduction bars that have a skew angle or angle relative to the rotating axle of the motor can be beneficial for proper and consistent torque output from the motor. However, traditional manufacturing processes have not been able to first, consistently set the skew angle in the induction rotor and second, maintain the skew angle after the manufacturing process is complete. Due to stress relaxation after casting or joining the induction rotor, significant skew angle variation is found as a result.

Accordingly, there is a need in the art for an improved process for manufacturing induction rotors having minimal skew angle variation that extends for the life of the induction motor in service.

SUMMARY

The present disclosure comprises a method for manufacturing an induction rotor. The method includes providing a lamination stack having a plurality of laminates and a plurality of conduction bars. The lamination stack has a first end and a second end opposite the first end. A retainer ring is installed on each of the first end and the second end of the lamination stack. The lamination stack is placed into a fixture. The first end of the lamination stack is rotated in an opposite rotational direction from the second end of the lamination stack to skew the conduction bars to an angle α. A plurality of vertical members are fixed to an outer perimeter of each of the plurality of laminates of the lamination stack. A plurality of hoop members are fixed to each of the plurality of vertical members and an outer edge of each of the plurality of conduction bars. A conduction ring is fixed on each of the first end and the second end of the lamination stack. An outer perimeter of the lamination stack is machined to remove the plurality of vertical members and the plurality of hoop members from the lamination stack.

In one example of the present disclosure, the lamination stack is provided having each of the laminates of the plurality of laminates include a plurality of slots equally spaced on an outside perimeter of the laminates forming a plurality of elongated grooves and one of the plurality of conduction bars are disposed in each of the elongated grooves of the plurality of elongated grooves.

In another example of the present disclosure, the retainer ring is installed in a groove formed by a notch on an inner edge of each of the plurality of conduction bars on each of the first end and the second end of the lamination stack.

In yet another example of the present disclosure, the retainer ring is installed in a groove formed by a notch on an outer edge of each of the plurality of conduction bars on each of the first end and the second end of the lamination stack.

In yet another example of the present disclosure, the plurality of vertical members are welded to the outer perimeter of the plurality of laminates of the lamination stack.

In yet another example of the present disclosure, the plurality of hoop members are welded to the plurality of vertical members and the outer edge of the plurality of conduction bars.

In yet another example of the present disclosure, the conduction rings are fixed on each of the first end and the second end of the lamination stack by forming a conduction ring on each of the first end and the second end of the lamination stack by an over mold casting process.

In yet another example of the present disclosure, the conduction ring is fixed on each of the first end and the second end of the lamination stack by one of welding and brazing the conduction ring on each of the first end and the second end of the lamination stack.

The above features and advantages and other features and advantages of the present disclosure are readily apparent from the following detailed description when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

FIG. **1** is a flow chart detailing a method of manufacturing induction rotors according to the principles of the present disclosure;

FIG. **2** is a perspective view of a partially assembled induction rotor according to the principles of the present disclosure;

FIG. **3**A is a perspective view of a partially assembled induction rotor according to the principles of the present disclosure;

FIG. **3**B is a perspective view of a partially assembled induction rotor according to the principles of the present disclosure;

FIG. **4**A is a side view of a conduction bar for an induction rotor according to the principles of the present disclosure;

FIG. **4**B is a side view of a conduction bar for an induction rotor according to the principles of the present disclosure;

FIG. **5** is a perspective view of a partially assembled induction rotor held in a manufacturing fixture according to the principles of the present disclosure;

FIG. **6** is a perspective view of a partially assembled induction rotor according to the principles of the present disclosure;

FIG. **7** is a partial perspective view of a partially assembled induction rotor according to the principles of the present disclosure;

FIG. **8** is a perspective view of an induction rotor according to the principles of the present disclosure;

FIG. **9** is a top view of an induction rotor according to the principles of the present disclosure, and

FIG. **10** is a perspective view of an induction rotor according to the principles of the present disclosure.

DESCRIPTION

Examples of the present disclosure advantageously provide method of manufacturing an induction rotor for an induction style electric motor. Referring to the drawings, wherein like reference numbers refer to like components, FIG. **1** is a flow chart depicting the steps of a method **100** for manufacturing an induction rotor according the principles of the present disclosure. The method **100** will now be described using the flow chart of FIG. **1** in coordination with FIGS. **2-10** which illustrate various stages of assembly of the induction rotor after particular steps of the method **100**. For example, the first step **102** of the method **100** includes assembling a plurality of laminates **14** with a plurality of conduction bars **16** as shown in FIG. **2**. More particularly, the plurality of laminates **14** are formed into a lamination stack **18** which includes slots **20** in which are disposed one of the plurality of conduction bars **16**. The conduction bars **16** are spaced equally about the perimeter of the lamination stack **18**.

Referring now to FIGS. **3**A, **3**B, **4**A, and **4**B with continuing reference to FIG. **1**, in a second step **104** of the method **100** the lamination stack **18** and conduction bars **16** are secured together in a rotor assembly using one of a first retainer ring **22** and a second retainer ring **24**. The first retainer ring **22** is disposed in a groove **26** formed by a plurality of conduction bars **16**B having a first notch **28** on the inner edge **30** of the conduction bar **16**B proximate each of the ends **32** of the conduction bars **16**B. The first notches **28** of the plurality of conduction bars **16**B align to form the groove **26** when assembled with the lamination stack **18**.

Alternatively, the second retainer ring **24** is disposed in a groove **34** formed by a plurality of conduction bars **16**A having a second notch **36** on the outer edge **38** of the conduction bar **16**A proximate each of the ends **40** of the conduction bars **16**A. The second notches **36** of the plurality of conduction bars **16**A align to form the groove **34** when assembled with the lamination stack **18**.

A third step **106** of the method **100** places the assembled lamination stack **18** into a fixture **42** as shown in FIG. **5**. The fixture **42** includes an upper portion **44** and a lower portion **46** each having a plurality of radially extending members **48** disposed in the gaps **50** formed between the ends **32**, **40** of the conduction bars **16**. A fourth step **108** of the method **100** sets the skew angle α of the conduction bars **16** relative to the rotational axis i of the lamination stack **18** (as shown in FIG. **6**). The upper portion **44** of the fixture **42** rotates in the opposite direction from the lower portion **46** of the fixture **42**.

A fifth step **110** of the method **100** fixes a vertical member **52** to the individual laminates of the lamination stack **18**. The vertical member **52** is preferably welded to the laminates **14**, however other means of fixing the vertical member **52** to the laminates **14** may be considered without departing from the scope of the disclosure. For example, the vertical members **52** may be adhered to the laminates **14** using an adhesive or other type of metal joining technique. In this fifth step **110**, several vertical members **52** are joined to the lamination stack **18** around the perimeter of the lamination stack **18**. The result of this fifth step is shown in FIG. **7**. While FIG. **7** illustrates the conduction bars

A sixth step **112** of the method **100** fixes a plurality of hoop members **54** to the vertical members **52** and conduction bars **16**. Again, the preferred metal joining technique in the sixth step **112** is welding. Referring back to FIG. **6**, two hoop members **54** are used to permanently hold the lamination stack **18** and conduction bars **16** to the skew angle α set by the fixture **44**, however additional or fewer hoop members **54** may be fixed to the vertical members **52** and conduction bars **16** without departing from the scope of the disclosure so long as the result of the sixth step **112** is a permanently set skew angle α. While FIG. **7** illustrates the outer edge **38** of the conduction bar **16** extends beyond the outer perimeter of the lamination stack **18**, the disclosure contemplates that the outer edge **38** of the conduction bars **16** may be just below the outer perimeter of the lamination stack **18** without departing from the scope of the disclosure.

The seventh step **114** of the method **100** removes the lamination stack **18** with the permanently set skew angle α from the fixture **44** and prepares the lamination stack **18** to go through the eighth step **116** of installing conduction rings **56** on each end **58** of the lamination stack **18**. For the eighth step **116** of the method **100**, of several techniques that may be used to install or form the conduction rings **56** on the lamination stack **18**, those considered in the present method **100** include brazing or welding the conduction rings **56** on the ends of the conduction bars **16** (as shown in FIGS. **9** and **10**) or casting the conduction rings **56** in place using an over mold casting process (as shown in FIG. **8**). The over mold casting process includes placing the lamination stack **18** in a mold or die and pouring a metal alloy, preferably an aluminum alloy, into the mold such that the conduction rings **56** solidify in place at each end **58** of the lamination stack **18**.

Regardless of the technique used to install or form the conduction rings **56** on the lamination stack **18**, the ninth step **118** of the method includes removing the vertical members **52** and the hoop members **54** from the completed induction rotor assembly **60**. A machining technique may be used to separate the vertical members **52** and the hoop members **54** which also may remove other material from the outer perimeter **62** of the induction rotor assembly **60** to achieve a specified dimension.

While examples have been described in detail, those familiar with the art to which this disclosure relates will recognize various alternative designs and examples for practicing the disclosed structure within the scope of the appended claims.

The invention claimed is:

1. A method for manufacturing an induction rotor, the method comprising:
- providing a lamination stack comprising a plurality of laminates and a plurality of conduction bars, the lamination stack having a first end and a second end opposite the first end;
- installing a retainer ring on each of the first end and the second end of the lamination stack;
- placing the lamination stack into a fixture;
- rotating the first end of the lamination stack in an opposite rotational direction from the second end of the lamination stack to skew the conduction bars to an angle α;
- fixing a plurality of vertical members to a first outer perimeter of each of the plurality of laminates of the lamination stack;
- fixing a plurality of hoop members to each of the plurality of vertical members and an outer edge of each of the plurality of conduction bars;
- fixing a conduction ring on each of the first end and the second end of the lamination stack;
- machining a second outer perimeter of the lamination stack to remove the plurality of vertical members and the plurality of hoop members from the lamination stack.

2. The method of claim **1** wherein providing the lamination stack comprising the plurality of laminates and the plurality of conduction bars, the lamination stack having the first end and the second end opposite the first end further comprises providing the lamination stack comprising the plurality of laminates and the plurality of conduction bars, the lamination stack having the first end and the second end opposite the first end, and wherein each of the laminates of the plurality of laminates include a plurality of slots equally spaced on an outside perimeter of the laminates forming a plurality of elongated grooves and one of the plurality of conduction bars are disposed in each of the elongated grooves of the plurality of elongated grooves.

3. The method of claim **1** wherein installing the retainer ring on each of the first end and the second end of the lamination stack further comprises installing the retainer ring in a groove formed by a notch on an inner edge of each of the plurality of conduction bars on each of the first end and the second end of the lamination stack.

4. The method of claim **1** wherein installing the retainer ring on each of the first end and the second end of the lamination stack further comprises installing the retainer ring in a groove formed by a notch on an outer edge of each of the plurality of conduction bars on each of the first end and the second end of the lamination stack.

5. The method of claim **1** wherein fixing the plurality of vertical members to the outer perimeter of the plurality of laminates of the lamination stack further comprises fixing the plurality of vertical members to the outer perimeter of the plurality of laminates of the lamination stack by welding.

6. The method of claim **1** wherein fixing the plurality of hoop members to the plurality of vertical members and the outer edge of the plurality of conduction bars further comprises fixing the plurality of hoop members to the plurality of vertical members and the outer edge of the plurality of conduction bars by welding.

7. The method of claim **1** wherein fixing the conduction ring on each of the first end and the second end of the lamination stack further comprises fixing the conduction ring on each of the first end and the second end of the lamination stack by forming the conduction ring on each of the first end and the second end of the lamination stack by an over mold casting process.

8. The method of claim **1** wherein fixing the conduction ring on each of the first end and the second end of the lamination stack further comprises fixing the conduction ring on each of the first end and the second end of the lamination stack by one of welding and brazing the conduction ring on each of the first end and the second end of the lamination stack.

9. A method for manufacturing an induction rotor, the method comprising:

providing a lamination stack comprising a plurality of laminates and a plurality of conduction bars, the lamination stack having a first end and a second end opposite the first end, and wherein each of the laminates of the plurality of laminates include a plurality of slots equally spaced on an outside perimeter of the laminates forming a plurality of elongated grooves and one of the plurality of conduction bars are disposed in each of the elongated grooves of the plurality of elongated grooves;

installing a retainer ring on each of the first end and the second end of the lamination stack;

placing the lamination stack into a fixture;

rotating the first end of the lamination stack in an opposite rotational direction from the second end of the lamination stack to skew the conduction bars to an angle α;

fixing a plurality of vertical members to a first outer perimeter of each of the plurality of laminates of the lamination stack;

fixing a plurality of hoop members to each of the plurality of vertical members and an outer edge of each of the plurality of conduction bars;

fixing a conduction ring on each of the first end and the second end of the lamination stack;

machining a second outer perimeter of the lamination stack to remove the plurality of vertical members and the plurality of hoop members from the lamination stack.

10. The method of claim **9** wherein installing the retainer ring on each of the first end and the second end of the lamination stack further comprises installing the retainer ring in a groove formed by a notch on an inner edge of each of the plurality of conduction bars on each of the first end and the second end of the lamination stack.

11. The method of claim **9** wherein installing the retainer ring on each of the first end and the second end of the lamination stack further comprises installing the retainer ring in a groove formed by a notch on an outer edge of each of the plurality of conduction bars on each of the first end and the second end of the lamination stack.

12. The method of claim **9** wherein fixing the plurality of vertical members to the outer perimeter of the plurality of laminates of the lamination stack further comprises fixing the plurality of vertical members to the outer perimeter of the plurality of laminates of the lamination stack by welding.

13. The method of claim **12** wherein fixing the plurality of hoop members to the plurality of vertical members and the outer edge of the plurality of conduction bars further comprises fixing the plurality of hoop members to the plurality of vertical members and the outer edge of the plurality of conduction bars by welding.

14. The method of claim **13** wherein fixing the conduction ring on each of the first end and the second end of the lamination stack further comprises fixing the conduction ring on each of the first end and the second end of the lamination stack by forming the conduction ring on each of the first end and the second end of the lamination stack by an over mold casting process.

15. The method of claim **13** wherein fixing the conduction ring on each of the first end and the second end of the lamination stack further comprises fixing the conduction ring on each of the first end and the second end of the lamination stack by one of welding and brazing the conduction ring on each of the first end and the second end of the lamination stack.

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